The Effects of Kind of Rootstock and Kind, Length and Location of Interstock on Pear Tree Performance and Fruit Quality

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INTRODUCTION

There has been a great deal of interest in pear rootstocks and interstocks in the Pacific Coast states but this has been particularly from the standpoint of blight resistance and black-end. Reimer (46) twice visited the Orient, in 1917 and 1919, and brought back many Oriental species for testing. These, together with practically all the known species and several hundred varieties imported from Europe, Africa and Asia, were planted at the Southern Oregon Branch Experiment Station near Medford in the Rogue River Valley. This planting constituted what was probably the most comprehensive pear collection in the world (46). The Oriental species were tested primarily for resistance to blight but the principal commercial varieties were grafted onto each of the most promising species to test for orchard performance.

Before this time the Japanese species, Pyrus pyrifolia Nakai, had been introduced and was used as a rootstock in a limited way by propagators. During World War I, seed of Pyrus communis L., the common European pear, was difficult to obtain from France so there was an almost complete swing to Japanese seedlings for propagation. Soon after trees on this rootstock started to produce, it was noted that some of the fruits had an abnormal blossom end. These pears were hard and frequently black at the blossom end and the condition came to be known as hard-end or black-end. It was soon shown that this trouble was associated with the Japanese rootstock. It also appeared in lesser amounts in fruit grown on some of the other Oriental roots. As a result it seemed most prudent to use the P. communis seedlings as rootstocks since they had a long history of satisfactory service. In the meantime several hundred acres of pears of various varieties on different Oriental roots had been planted in the Medford area on a trial basis to determine their commercial usefulness.

As blight was still a problem, the search for a resistant rootstock was continued but the emphasis changed from Oriental species to selecting resistant P. communis seedlings. This was successful and several resistant seedlings were found in the mid-1930's (47). As these were capable of transmitting blight resistance, their seedlings were used for propagation to a limited extent from about 1940 to 1955.

While a resistant rootstock was being sought, there was equal effort being spent to find a blight resistant variety for use as an interstock. Several of these were located and again several hundred acres of orchard were planted to test them.

During this same time some of the first commercial varieties planted in the Rogue River Valley were found to be inferior from the standpoint of quality and production characteristics. As the pear tree grafts readily and recovers quickly, these varieties were topworked. Changes in consumer preferences, the development of the Comice gift-box trade, introduction of new varieties, recognition of undesirable varietal traits, evidence of disease susceptibility, etc., were additional reasons for thousands of acres of pears being topworked in the Medford district. In some cases orchards have been topworked two, three, or even four times, resulting in a compound "sandwich" effect. All of these combinations grew well, and while some scions grew larger than the stock and some smaller, no obvious failure developed.

Extensive pear storage and ripening tests were made with Southern Oregon fruit but this was never related back to any rootstock or interstock effect. With one possible exception, the orchards chosen for the tests were all on P. communis root with no interstocks. These tests were made in the mid-1920's before so many orchards were topworked.

The possibility of trouble at the graft union was first recognized in 1954 in some young trees on blight-resistant rootstock. In investigating this, Higdon (36) showed that the tissues of stock and scion had failed to unite in certain areas and that it was a clear case of delayed incompatibility. This emphasized the need for a closer look at the multitude of stock-scion combinations and their relation to tree performance and fruit quality.

REVIEW OF LITERATURE

Graft congeniality was well described by Husmann (38) as a condition present when one variety being grafted on another behaved as if the stock were grafted with a scion of itself, the union being perfect and the behavior of the plant being the same as that of an entire ungrafted plant. This definition permits perfection of congeniality but hints at difficulty in achieving it. That complete congeniality is difficult to achieve is attested by the many who have described a lack of it.

Waugh (62) was one of the first to examine the physical makeup of good and bad unions. He found an interlocking of cells at the interface of the two tissues in good unions and the deposition of loose meristematic tissue at the junction of imperfect ones. A careful examination was made of many graft unions by Bradford and Sitton (11). They found that uncongeniality was due to discontinuous phloem rather than to faulty xylem unions. This has been confirmed by observations of others (35, 42, 44, 45, 57).

That congeniality is a matter of degree is well recognized. Shaw and Southwick (52) suggest the term incompatibility for those cases where plants die rather soon from stock or scion failure. Uncongeniality would be reserved for those cases where the plants live but show modification of stock or scion. The literature in this field was well reviewed by Argles (6). Similar literature reviews (11, 35, 48, 49) have thoroughly covered the field, so that only literature which pertains to this project will be cited here.

In addition to the discontinuity of tissues and the accumulation of parenchyma cells at the union already cited, there are a number of other indicators of degree of congeniality. These were reviewed and discussed by Chang (13) and include the following:

1. Initial "take" and subsequent growth.
2. Premature coloration, defoliation, fruit bud formation, and dieback.
3. Decline of annual wood growth.
4. Decline of new root growth.
5. Change in stock/scion diameter ratio.
6. Mechanical weakness of union.
7. Obstruction at the union.
8. Starch accumulation at the union.
9. Swelling at the union.

The relative ability of roots and tops to retain their own characteristics and to change the vegetative character of their graft partner has been extensively investigated (5, 8, 48, 59, 60). The influence of the interstock has also received attention (20, 21, 29, 41, 54, 56, 58). There seems little doubt that the top, the root, the rootstock stem, and the interstock all exert influences upon the vegetative nature of all units in a compound plant.

The influences of these integral parts upon the physiology of the tree are less well known (50). Friedrich (19) found that each rootstock and scion variety on its own roots had a characteristic curve of catalase activity. After grafting, some scions retained the same curve of activity but in most cases the new tree developed a curve of its own.

He also found that the transpiration rate of Bartlett pear was affected by different rootstocks and interstocks. However, according to Warne and Wallace (61) Knight found that varieties retained their normal transpiration rate when grafted onto seedlings with high transpiration rates.

Rootstocks do change the chemical composition of the scion variety, including that of the stem, shoots, leaves and fruits (12, 23, 39, 51, 61). Along with this change in chemical composition is associated a change in fruit quality. This has been extensively studied in the case of citrus (9, 22, 24, 25, 26, 27, 28, 53). The degree of rootstock influence varies from variety to variety. The rootstock producing the best quality in one citrus fruit does not produce the best quality in them all. Likewise, rootstocks contributing to the most desirable development of one quality factor do not necessarily develop best quality in all factors.

There has been no such complete investigation of rootstock and interstock effects on quality of deciduous fruits, although Phillips and Nelson (43) have found differences in apple quality due to both rootstocks and interstocks. In the case of pears the disorder called black-end has been associated with Japanese roots (34). Allen (1, 2, 3) ripened Bartlett pears from trees on Japanese and on French roots grown in various districts. He did find some quality differences but they were minor and varied from district to district.

Numerous other investigators (7, 18, 30, 50) give casual mention to fruit quality as it is affected by rootstock but this has in most cases been a minor part of a general stock-scion investigation. The influence of rootstock on pear quality has been so lightly held that it is generally overlooked as a factor to be considered in the selection of a rootstock (14, 15, 47) and was not listed as a possible factor affecting fruit quality in a review of literature of factors affecting fruit quality preparatory for a comprehensive storage and ripening investigation (40).

Interstock influences on fruit quality have also been given some general notice (19); instances have also been reported where plum maturity was materially influenced by the interstock (37). A reciprocal effect was also noted by Heinicke (33) where apples borne on an interstock were materially altered as to both external and internal quality. This effect was lessened if many interstock leaves were allowed to remain.

The rootstock seems even to impart a measure of disease resistance, or susceptibility, to the top (9, 16), but while this association has been clearly noted it has not been adequately explained.

MATERIALS AND METHODS

This work is divided into three parts. Part one deals with detailed measurements of trunk, interstock, and graft union of mature, fully-developed trees, and their possible relationship to tree size and yield. Part two is a nursery test to determine the influence of the type of tissue (root or stem) in which the bud was placed, the influence of microclimate, and the difference in tree growth between a vigorous and a non-vigorous scion variety. Part three deals with the effects of rootstock and interstock on the storage and dessert quality of the fruit.

Description of orchards

No one block could be located with all desired characters of rootstocks and interstocks, so it was necessary to make observations and obtain fruit from four different orchards. These are described as follows:

Orchard number 1 is on a piece of uniform, Meyer clay adobe soil. It is one of the older orchards in the area, having been planted in 1897, in rows fifty trees long in the following order: seven rows of Bosc, one row of Seckel, fourteen rows of Comice, five rows of Anjou, eight rows of Clairgeau. These scions were originally propagated on French seedling rootstocks. The graft unions were all at or above the ground line and in no case were any scion roots observed. During the years some trees in each row have been lost as a consequence of blight infection and other causes. Although replacements have been grown, these were not made a part of this study.

In the mid-1920's the row of Seckel and eleven rows of Comice adjoining the Bosc were topworked to Bosc, leaving interstocks of varying lengths. The other three rows of Comice were adjoining the Anjous and were topworked to Anjou. Also seven rows of Clairgeau were topworked to Anjou. The remaining Clairgeau row was topworked at this time to Howell and then to Anjou about 1940. The number of trees together with the variety, interstock and rootstock are shown in Table 1.

Orchard number 2 is a nearby block, on the same Meyer clay adobe soil type, planted to Bartlett on P. communis rootstock in 1902. In 1904 every third row was topworked to Winter Nelis, leaving a short Bartlett interstock. Ten replants made at that time were Winter Nelis on P. communis rootstock. Five years later an additional two rows (35 trees) of Winter Nelis on P. communis rootstock were planted adjoining this block. The trees in these blocks are now large and fully grown. The number of trees and the variety, interstock and rootstock are listed in Table 1.

Orchard number 3 is close to orchard number 1 and, while it is also on Meyer clay adobe soil, the soil is not uniform. It has a low wet streak diagonally across the rows and a shallow bench juts into one side. While these irregularities impair the usefulness of the block, its layout is such that much good information is still obtainable. The trees were planted in December 1923 as a block to test various trunk and interstock combinations. Twenty-five rows were planted with six Anjou and eight Seckel trees in each row. The twenty-one different rootstock and interstock combinations and four duplications are shown in Table 2.

TABLE 1

NUMBER, VARIETY, INTERSTOCK AND ROOTSTOCK OF TREES IN ORCHARDS 1 AND 2

Number of trees	Variety	Interstock	Rootstock
		Orchard No. 1	
286	Bosc	none	*P. communis*
35	Bosc	Seckel	*P. communis*
425	Bosc	Comice	*P. communis*
117	Anjou	Comice	*P. communis*
208	Anjou	none	*P. communis*
307	Anjou	Clairgeau	*P. communis*
28	Anjou	Howell/Clairgeau	*P. communis*
		Orchard No. 2	
102	Bartlett	none	*P. communis*
60	Winter Nelis	Bartlett	*P. communis*
45	Winter Nelis	none	*P. communis*

TABLE 2

INTERSTOCK AND ROOTSTOCK COMBINATIONS IN ORCHARD NO. 3 WITH SCION VARIETIES ANJOU AND SECKEL

Row	Interstock	Rootstock
1	Old Home	P. ussuriensis
2	Old Home	P. calleryana
3	Old Home	P. communis
4	Old Home	P. betulaefolia
5	Old Home	P. pyrifolia
6	Variolosa	P. ussuriensis
7	Variolosa	P. calleryana
8	Variolosa	P. communis
9	Variolosa	P. betulaefolia
10	Variolosa	P. pyrifolia
11	Farmingdale	P. ussuriensis
12	Longworth	P. ussuriensis
13	Hung Guar Li	P. ussuriensis
14	Hung Guar Li	P. calleryana
15	Old Home	P. communis
16	Old Home	P. ussuriensis
17	Old Home	P. calleryana
18	Tolstoy	P. ussuriensis
19	Tolstoy	P. calleryana
20	Tolstoy	P. communis
21	P. pyrifolia	P. calleryana
22	P. calleryana	P. calleryana
23	Winter Nelis	P. communis
24	Old Home	P. ussuriensis
25	none	P. calleryana

All of these trees were planted with the lower graft union at or slightly below the soil surface. This is not sufficiently deep to encourage general rooting but will permit rooting of varieties which root readily. Old Home roots readily and many interstocks of this variety had struck root. The difficulties involved in determining whether a root arose from rootstock tissue just below the union or from interstock tissue just above the union were such that it was not attempted. In the case of Old Home, it not only roots readily but the roots send up suckers. While this is not a certain test on any given tree, it does permit an over-all appraisal and it showed that Old Home had frequently rooted. There were no rootsprouts observed from any other interstock.

Of the five species used here as rootstocks one, P. communis, is known as French, while the other four, Pyrus betulaefolia Bunge, P. calleryana Decne., P. ussuriensis Max., and P. pyrifolia, are Oriental species. Their origin is well known but a word may be in order regarding the background of some of the interstocks. Old Home and Farmingdale are pure P. communis. They originated as chance seedlings and are blight resistant. Winter Nelis is pure P. communis and is a commercial variety. Longworth is principally P. communis but may have a small amount of Oriental ancestry. The Variolosa used here is not true P. variolosa Wallich, but is of uncertain origin, probably resulting from a cross of P. pashia Buch.-Ham. x P. communis (45) hence in this case it is referred to as a variety. Tolstoy originated as a seedling resulting from a cross between Clapp Favorite and P. ovoidea Rehder. Hung Guar Li is a blight-immune selection of P. ussuriensis. The P.

pyrifolia and P. calleryana used as interstocks are selected strains of their species.

The interstocks used here had been headed and branched at the two-foot level and grafted to Anjou or Seckel in the framework branches at the three- to four-foot level.

Orchard number 4 is a part of the Southern Oregon Branch Experiment Station rootstock block where the five most promising pear species were budded to Anjou and planted side by side for comparative purposes. These species were the same as those used as rootstocks in orchard number 3, namely P. communis, P. betulaefolia, P. calleryana, P. ussuriensis and P. pyrifolia. The soil in this orchard is Neal silty clay loam and is much lighter than the heavy clay soil in the other three orchards. The trees were planted so the graft unions were six inches above ground. This precluded any possibility of the scions rooting.

Tree measurements

Detailed measurements of trunk, interstock, and graft union were made in orchards 1 and 2 to compare the relationship between:

1. Height of graft union and overgrowth.
2. Height of graft union and circumference.
3. Length of interstock and overgrowth.
4. Length of interstock and trunk circumference.
5. Amount of overgrowth at graft union and trunk circumference.

In order to compare these, the following measurements were taken:

1. Height of graft union from ground level. Many of the unions were at ground level but the height of others was measured in inches above ground level.

2. Length of interstock in inches.
3. Circumference of the scion or interstock at 15 inches above ground level.
4. Amount of overgrowth at union. Smooth unions were given a value of 0. If the trunk was up to 4 inches larger in circumference, it was given a value of +1. If the root was up to 4 inches larger than the scion it was given a value of -1. For each additional 4 inches difference in circumference, this value was increased by a value of one. Thus if the scion was 12 inches larger in circumference than the root, it was assigned a value of +3. The conversion of overgrowth to inches of diameter is based on the estimated difference in circumference between the stock and scion of 4 inches for each unit of overgrowth.

Less detailed observations and measurements of overgrowth at the unions and of trunk circumference of trees were made in orchard number 3.

Certain of the tables where these measurements are tabulated list a maximum and minimum size and, in parenthesis, the number of trees measured. The standard deviation may be estimated from the range (max-min) by the following formula:

$$\frac{\text{max-min}}{\text{twice entry in parenthesis}} = S \quad (17).$$

Nursery test

As these previously described measurements were made on old, fully-developed trees, they give no indication of the development of these relationships in young trees. To provide information on this, a nursery test was also set up. Seedlings resulting from crosses between known parents were used. Seventy seedlings of Packham's Triumph x Red

Bartlett, seventy of Comice x Red Bartlett, and twenty of Comice x Forelle were set out in nursery rows in March, 1958. All seedlings of Packham's Triumph x Red Bartlett and Comice x Red Bartlett were divided into groups of ten and planted with the root-stem transition zone at the ground line except groups 6 and 7 which were planted so the transition zone was 4 inches above ground. These trees were budded in May of 1958 to Comice and Bartlett. All of the budwood of each variety was selected from a single tree to minimize the possibility of variations due to virus or bud mutations. Five trees of each group of ten were budded to Comice, a variety with a rapidly enlarging trunk, and five to Bartlett, the trunk of which enlarges more slowly. The buds were placed at various heights and in different tissues as listed in Table 3.

One half of the Comice x Forelle seedlings were budded to Comice and one half to Bartlett, but all were budded 4 inches above the ground line.

The seedlings were budded in this manner to test the influence of tissue in which the bud was placed on the graft union and on tree behavior. There is also the possibility that any difference in behavior is not due to tissue difference but is a response to microclimate. This was to be tested by mounding soil around some high budded trees and planting some trees high so the buds could be placed in lower stem tissue and in root tissue and still be 4 inches above the soil. In these cases, the crown of the tree and the upper portions of the roots were left exposed when planted.

TABLE 3

LOCATION OF BUDS IN NURSERY TREES

Group	Description
1.	Budded 10 inches above the ground line.
2.	Budded 4 inches above the ground line.
3.	Budded 4 inches above the ground and the soil banked up to the bud.
4.	Budded in the stem tissue just above the transition zone.
5.	Budded in the root tissue just below the transition zone.
6.	Budded in stem tissue just above the transition zone in trees planted so the bud could be set 4 inches above the ground line.
7.	Budded in root tissue just below the transition zone in trees planted so the bud could be set 4 inches above the ground line.

Storage and dessert quality

The influence of rootstock and interstock on the storage and dessert quality of pears was tested in all four orchards. Fruit samples from all of the combinations were gathered at the time the fruit was commercially harvested. While some cork spot and a small amount of hard-end was observed, no pears obviously affected were selected in the samples. Thirty-fruit samples were picked directly from the trees in each plot and ten of these were pressure-tested for maturity with the Oregon Pressure tester and expressed juice was tested for soluble solids with a refractometer. The remaining twenty pears were placed in cold storage at 31° F and kept until the very end of their storage season. It was felt that if there were any weaknesses they would be most likely to show up late in the season. This is important to areas such as Medford, Oregon, where much of the fruit is kept over a long storage season.

Pears are very sensitive to temperature conditions. For long storage life they must be stored just above their freezing point. Commercially this is in the range of 29° to 31° F. When removed from storage they ripen best at a temperature between 60° to 70° F, with a high relative humidity. This induces rapid ripening and minimizes shrivel and core breakdown.

The use of the pressure tester, storage and ripening procedures, and terminology used in describing the fruit are all standardized. These are based on procedures followed by Hartman *et al.* (31, 32) in earlier studies of pear storage and maturity.

RESULTS

Stock-Scion Relationship in Mature Trees

Overgrowth as related to height of graft union.

All varieties, except Bartlett, made reasonably smooth unions with the P. communis rootstock if the unions were at or below the ground line. Where the graft unions were above the ground line, there was frequently a disparity in size between the stock and scion. This size difference was progressively greater the higher the unions were above the ground. This increasing size difference was significant for all varieties in Table 4. There was also a marked difference in this growth relationship between varieties. The Bartlett scion was never larger and generally smaller than the French rootstock, even when grafted at the ground line. Comice, on the other hand, was never smaller and in a few cases was larger than the rootstock if the union was at the ground line; it was frequently larger when the union was above ground. Bosc, Anjou and Clairgeau were in between these extremes. These relationships are set forth in Table 5.

Scion circumference as related to height of graft union.

There seems to be no difference in trunk circumference that can be accounted for by the varying height of the graft union, Table 6. While the circumference of Bosc, and each of the other varieties, varies from one height to another, these variations do not make a consistent pattern either within a variety or between varieties.

TABLE 4

AVERAGE AMOUNT[1] AND RANGE OF OVERGROWTH IN INCHES OF DIAMETER BETWEEN P. COMMUNIS ROOTSTOCK AND VARIOUS SCIONS AS RELATED TO HEIGHT OF GRAFT UNION

Scion variety		Height of graft union (inches)					
		0	2	4	6	8	10
Bosc*	Average	0.1 (22)	0.6 (17)	0.7 (60)	1.2 (68)	1.4 (31)	1.9 (18)
	Range	-1 0	-4 1	-2 2	-4 2	-5 2	-6 2
Comice*	Average	0.1 (118)	0.5 (69)	1.1 (64)	1.1 (51)	2.0 (18)	2.7 (7)
	Range	0 2	-1 2	-1 5	-2 4	-2 5	0 5
Anjou*	Average	0 (23)	.9 (8)	1.8 (38)	2.3 (58)	2.9 (37)	2.3 (17)
	Range	0 0	-1 0	-4 1	-5 1	-6 0	-4 1
Clairgeau*	Average	0 (106)	0.3 (9)	1.6 (127)	2.5 (53)	2.7 (7)	
	Range	-1 0	-1 0	-4 0	-4 0	-1 -4	
Bartlett*	Average	1.4 (53)	2.7 (21)	3.3 (23)	4.1 (4)		
	Range	-5 0	-4 -1	-5 -1	-8 -1		

[1] The figures in parenthesis are the number of trees on which the average is based.

* Correlation coefficient significant at least at the .05 level for each variety.

TABLE 5

OVERGROWTH AS RELATED TO VARIETY AND HEIGHT OF GRAFT UNION

	Union at ground line			Union above ground		
Scion variety	% of trunks with smooth union	% of trunks larger than rootstock	% of trunks smaller than rootstock	% of trunks with smooth union	% of trunks larger than rootstock	% of trunks smaller than rootstock
Bartlett	27	0	73	0	0	100
Clairgeau	96	0	4	12	0	88
Anjou	100	0	0	14	0	86
Bosc	91	9	0	46	17	37
Comice	92	8	0	48	38	14

All rootstocks are _P_. _communis_.

TABLE 6

AVERAGE AMOUNT[1] AND RANGE OF SCION CIRCUMFERENCE IN INCHES AS RELATED TO HEIGHT OF GRAFT UNION

Scion variety		Height of graft union					
		0	2	4	6	8	10
Bosc	Average	54.6 (22)	56.9 (17)	59.8 (60)	58.0 (68)	60.3 (31)	57.3 (18)
	Range	45 67	47 67	53 71	47 75	45 67	44 67
Comice	Average	70.0 (118)	70.0 (69)	69.7 (64)	67.3 (51)	69.6 (18)	62.3 (7)
	Range	46 82	53 85	48 84	44 80	57 85	50 71
Anjou	Average	56.2 (23)	56.2 (8)	56.2 (38)	55.3 (58)	55.5 (37)	58.4 (17)
	Range	47 67	48 71	48 68	43 69	37 70	51 66
Clairgeau	Average	56.5 (106)	55.9 (9)	56.9 (127)	56.3 (53)	54.4 (7)	
	Range	40 73	46 67	45 73	45 66	45 64	
Bartlett	Average	39.8 (53)	40.1 (21)	41.7 (23)	38.7 (4)		
	Range	34 47	28 46	31 49	34 44		

All rootstocks are P. communis.

[1] The figures in parenthesis are the number of trees on which the average is based.

Correlation coefficient not significant for any variety.

Overgrowth as related to length of interstock

There was no consistent relationship between the length of Comice interstock and the amount of overgrowth. The extremes of overgrowth at the Comice/P. communis union were 1.4 inches and 0.4 inches in circumference and these occurred in the interstock length groups of 51-60 inches and 61-70 inches respectively. The greatest overgrowths at the Clairgeau/P. communis unions were in the shorter interstock length groups, but the difference was not significant (Table 7).

Scion circumference as related to length of interstock

As noted earlier, the trees in orchard number 1 are now past sixty years old and were topworked about thirty-five years ago. This is one of the pioneer orchards in the valley and tree-training methods were not standardized when it was planted. Hence some of the trees had excessively long trunks before scaffold limbs appeared. When the trees were topworked, those with long trunks were severly cut back and grafted low so a low head could be developed. This accounts for the great disparity in length of interstock.

There is now a consistent relationship between the length of interstock and trunk circumference (Table 8). The Comice interstock with both Bosc and Anjou tops and Clairgeau interstock with Anjou top show a very consistent increase in trunk circumference with increase in length of interstock.

Scion circumference as related to overgrowth

The relationship of the circumference of the scion trunk to overgrowth is shown in Table 9. Smooth unions are represented as 0. Where

TABLE 7

AVERAGE AMOUNT[1] AND RANGE OF OVERGROWTH IN INCHES OF DIAMETER AS RELATED TO LENGTH OF INTERSTOCK

		Length of interstock in inches						
Interstock		31-40	51-50	51-60	61-70	71-80	81-90	91-100
Comice*	Average	0.7 (110)	1.2 (43)	1.4 (40)	0.4 (30)	0.7 (85)	0.5 (25)	0.8 (3)
	Range	-1 4	-1 6	-4 7	-1 1	-2 4	-1 2	0 1
Clairgeau*	Average		1.7 (18)	1.8 (22)	1.3 (64)	1.3 (137)	1.0 (54)	0.9 (10)
	Range		-4 0	-4 0	-4 0	-4 0	-4 0	-4 0

Rootstocks are P. communis.

[1] The figures in parenthesis are the number of trees on which the average is based.

* Correlation coefficient not significant for either variety.

TABLE 8

AVERAGE AMOUNT[1] AND RANGE OF SCION CIRCUMFERENCE IN INCHES AS RELATED TO LENGTH OF INTERSTOCK

Scion and interstock variety*		Length of interstock in inches 21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
Bosc/Comice	Average	65 (75)	67 (110)	68 (43)	68 (40)	73 (30)	72 (85)	76 (25)	79 (3)
	Range	37 78	48 81	52 85	55 82	61 81	55 84	67 85	75 85
Anjou/Comice	Average				56 (9)	64 (9)	65 (56)	67 (24)	72 (14)
	Range				46 69	50 72	52 79	57 78	64 86
Anjou/Clairgeau	Average			50 (18)	53 (22)	56 (64)	57 (137)	60 (54)	61 (10)
	Range			41 64	45 67	46 67	46 73	48 73	57 66

All rootstocks are _P. communis_.

[1] The figures in parenthesis are the number of trees on which the average is based.

* Correlation coefficient significant at least at the .05 level for each combination.

TABLE 9

AVERAGE AMOUNT[1] AND RANGE OF SCION CIRCUMFERENCE IN INCHES AS RELATED TO OVERGROWTH ON P. COMMUNIS ROOTSTOCK

Scion variety		Degree of overgrowth						
		-5 and -4	-3	-2	-1	0	+1	+2
Comice	Average		57.0 (3)	66.2 (8)	68.2 (33)	69.4 (253)	69.0 (70)	65.9* (32)
	Range		51 61	62 80	50 84	46 85	55 85	45 78
Bosc	Average	49.0 (3)	57.8 (13)	59.3 (30)	60.2 (53)	59.5 (140)	56.1 (31)	54.2* (14)
	Range	48 51	47 68	46 72	48 72	46 73	44 68	45 70
Anjou	Average	49.8 (12)	51.3* (33)	56.7 (65)	58.8 (50)	58.5 (45)	60.3 (3)	
	Range	37 56	40 62	46 73	48 81	48 69	59 62	
Clairgeau	Average		54.7* (27)	55.9 (63)	56.6 (89)	57.4 (128)		
	Range		45 64	45 72	45 66	40 73		
Bartlett	Average	38.7 (3)	41.6* (26)	40.5 (30)	39.7 (24)	39.1 (18)		
	Range	36 41	32 49	28 46	31 47	33 43		

[1] The figures in parenthesis are the number of trees on which the average is based.

* Difference between means of indicated number and number in column 0 significant at .05 level.

the scion is larger than the stock it is given a + value, but if the scion is smaller than the stock it is given a - value.

Where Comice is used as a scion, the circumferences are greatest where the unions are most nearly smooth. The 0, +1, and -1 values are all essentially alike, but as the amount of overgrowth increases either because the scion is larger or because it is smaller than the stock, the trunk circumference decreases. With Bosc, this area of greatest trunk circumference shifts a little and is centered on the 0, -1 and -2 values of overgrowth. The +2 values of overgrowth are associated with smaller trunk circumferences. With Anjou and Clairgeau, there were only three cases out of five hundred where the trunk was larger than the root, so for practical purposes there were no + values of overgrowth. The greatest circumferences, while tending to be smaller at the -1 and -2 values, were not greatly different from the 0 value. However at the -3 value, the circumferences of both varieties dropped off materially, especially in Anjou.

The Bartlett variety seems to upset the consistency of this relationship. It has the largest trunk circumferences at the -3 overgrowth. This increase in trunk circumference is consistent with each increase in overgrowth to -3. The few trees with greater overgrowth have trunks of smaller circumference. It was noted earlier (Table 6) that the Bartlett trees with unions four inches above ground level also had the largest circumference. As most of these also had a -3 overgrowth it is difficult to determine if the greater circumference is related to position of union or to overgrowth. However the figures indicate a better relationship between overgrowth and circumference.

Among the varieties, there also was a relationship between overgrowth and trunk circumference. As different varieties grow more or less stocky trunks, comparisons between varieties may be meaningless. To get around this, the average circumference was obtained for those trunks which made a smooth union with the rootstock. In these cases the trunk and rootstock would be the same size, so in actuality it amounts to a comparison of the rootstock stems. Table 10 shows that, between varieties, the less the scion/stock ratio, the smaller is the circumference of both scion and stock. It is likely that a scion/stock ratio of 1 or slightly above would represent the maximum. This is indicated by smaller circumferences in those cases where the scion materially overgrew the stock.

It should be recognized here that had the Bosc, Anjou and Winter Nelis growing directly on *P. communis* been topworked when thirty years old their circumferences would probably be somewhat less.

Reciprocal scion--interstock relations

In the complex of Winter Nelis/*P. communis*, Winter Nelis/Bartlett/*P. communis*, and Bartlett/*P. communis* trees there were some size relationships apparent. The trunks of Winter Nelis/*P. communis* are larger than the Winter Nelis trunks where a Bartlett stem piece is interposed. On the other hand the trunks of Bartlett/*P. communis* are smaller than the piece of Bartlett trunk interposed between Winter Nelis and *P. communis*. This is shown in Table 11.

As mature Winter Nelis trees are larger than mature Bartlett trees, it seems logical to refer to Winter Nelis as being more vigorous. These measurements then would indicate that the vigorous Winter Nelis top had

TABLE 10

TRUNK CIRCUMFERENCE OF VARIOUS VARIETIES AS RELATED TO AMOUNT OF OVERGROWTH

Scion/stock combinations	Ave. overgrowth[1] of all unions (inches of circ.)	Circ. of trees with smooth unions (inches of circ.)
Bosc/Comice/*P. communis*	+1.6 (425)	69.4 (253)
Anjou/Comice/*P. communis*	+1.1 (117)	63.2 (74)
Bosc/*P. communis*	-1.4 (286)	59.5 (140)
Winter Nelis/*P. communis*	-1.6 (10)	59.8[A] (7)
Anjou/Clairgeau/*P. communis*	-3.8 (307)	57.4 (128)
Bosc/Seckel/*P. communis*	-4.0 (35)	54.4 (14)
Anjou/*P. communis*	-6.3 (208)	58.5 (45)
Winter Nelis/Bartlett/*P. communis*	-6.8 (60)	47.5[A] (6)
Bartlett/*P. communis*	-7.1 (102)	39.1[A] (18)

[1] The figures in parenthesis are the number of trees on which the average is based.

[A] As these trees are five and seven years younger, they would normally be expected to be somewhat smaller than the other, older varieties.

TABLE 11

RELATIONSHIP BETWEEN INTERSTOCK AND TOP VARIETY

Variety/interstock combinations	Circumference in inches
Winter Nelis on _P. communis_	59.2
Winter Nelis on _P. communis_ with Bartlett interstock	53.4
Bartlett interstock	46.6
Bartlett on _P. communis_	40.2

been dwarfed by the less vigorous Bartlett interstock. It would also appear that the less vigorous Bartlett interstock had been invigorated by the vigorous Winter Nelis top.

In addition it appears that the increase in circumference of the Bartlett interstock (6.4 inches) due to the effect of the Winter Nelis top was almost exactly the same as the amount (5.8 inches) by which the circumference of the Winter Nelis trunk had been decreased by the influence of the Bartlett interstock.

Yield as related to trunk circumference

Yield records of four-tree units were obtained in blocks of Bosc/*P. communis* and Bosc/Comice/*P. communis* in 1958. The yields were compared to the trunk circumferences and it was found that there was a relationship between trunk circumference and yield. While this was not a strong relationship, it did exist in the trees both with and without an interstock, Table 12.

Yield as related to length of interstock

There clearly was no relationship existing between length of Comice interstock and yield of Bosc top. The correlation coefficient is not significant at the .05 level. The yield of trees with various length interstocks was as follows:

Under 40 inches	17.4 boxes
41-50 inches	17.1 boxes
51-60 inches	17.7 boxes
61-70 inches	17.0 boxes
71-80 inches	18.2 boxes

TABLE 12

AVERAGE[1] AND RANGE OF YIELD IN BOXES AS RELATED TO TRUNK CIRCUMFERENCE

Scion/stock combination		50-54	55-59	60-64	65-69	70-80	Av.
Bosc/*P. communis*[2]	Average	17.4 (5)	20.1 (12)	20.6 (16)	22.0 (2)		19.9
	Range	13-23	12-27	12-28	21-23		
Bosc/Comice/*P. communis**	Average	13.5 (1)	16.5 (1)	16.6 (9)	17.5 (24)	19.2 (15)	17.4
	Range			12-21	14-23	13-23	

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[1] The figures in parenthesis are the number of trees on which the average is based.

[2] Probability at .10 level.

* Correlation coefficient significant at .05 level.

Yield as related to presence of interstock

The Bosc/P. communis combination yielded 19.9 boxes per tree while the Bosc/Comice/P. communis tree averaged only 17.4 boxes per tree. This difference seemed to be related to the presence of the Comice interstock. The difference between means is significant at the .05 level.

Circumference of interstock as related to top variety

Trunk circumference measurements in orchard number 3 (Table 13) indicate that Old Home interstocks with Seckel tops are larger than they are with Anjou tops. Old Home interstocks were used in five rows adjacent to five rows with Variolosa interstocks. With Old Home the circumference averaged 44 inches with Seckel top and 37.8 inches with Anjou top. Where Variolosa interstock was used, this was reversed. In the five combinations, the circumference of Variolosa under Anjou averaged 44 inches and under Seckel only 40.2 inches. With other interstocks the differences were not large enough to pass judgement. The size relationship between the Anjou and Seckel tops and interstocks is shown in Table 14.

Tree size and condition as related to interstock

Most of the interstocks were satisfactory to all outward appearances but there were a few notable exceptions. Rows 11, 12, and 13 (see Table 2) were all on P. ussuriensis rootstock but row 11 had Farmingdale interstock and the trees of both Anjou and Seckel varieties were of satisfactory size and condition. Row 12 had Longworth interstock and the trees of both varieties were decidedly smaller and in a poorer state of vigor. This condition was further exaggerated in row 13, which had an

TABLE 13

TRUNK CIRCUMFERENCE, YIELD AND FRUIT SIZE AS RELATED TO ROOTSTOCK AND INTERSTOCK

	Old Home interstock			Variolosa interstock		
Rootstock	Trunk circ. inches	Yield boxes	Fruit size	Trunk circ. inches	Yield boxes	Fruit size
			Scion variety - Seckel			
P. betulaefolia	52	7.3	244	45	8.3	245
P. communis	46	4.8	250	39	4.4	269
P. calleryana	46	5.8	284	42	5.2	264
P. ussuriensis	40	4.8	282	37	3.7	275
P. pyrifolia	36	3.7	272	38	3.2	250
Average	44	5.3	266	40.2	5.0	261
			Scion variety - Anjou			
P. betulaefolia	46	8.0	128	45	9.0	132
P. communis	38	9.0	115	41	7.0	117
P. calleryana	34	5.7	150	49	8.0	116
P. ussuriensis	35	3.0	146	45	5.0	121
P. pyrifolia	36	5.0	135	40	6.0	129
Average	37.8	6.1	135	44	7.0	123

TABLE 14

RELATIVE DIAMETER OF VARIOUS INTERSTOCKS AND TWO SCION VARIETIES

Root-stock	Interstock	Compared to the interstock Anjou is	Compared to the interstock Seckel is
uss	Old Home	moderately smaller	slightly smaller
cal	Old Home	moderately smaller	slightly smaller
com	Old Home	moderately smaller	slightly smaller
bet	Old Home	moderately smaller	slightly smaller
pyr	Old Home	moderately smaller	slightly smaller
uss	Variolosa	moderately smaller	slightly smaller
cal	Variolosa	moderately smaller	slightly smaller
com	Variolosa	moderately smaller	slightly smaller
bet	Variolosa	moderately smaller	slightly smaller
pyr	Variolosa	moderately smaller	slightly smaller
uss	Farmingdale	moderately smaller	slightly smaller
uss	Longworth	moderately smaller	moderately smaller
uss	Hung Guar Li	slightly larger	slightly larger
cal	Hung Guar Li	slightly larger	slightly larger
com	Old Home	moderately smaller	slightly smaller
uss	Old Home	moderately smaller	slightly smaller
cal	Old Home	moderately smaller	slightly smaller
uss	Tolstoy	slightly smaller	equal
cal	Tolstoy	slightly smaller	equal
com	Tolstoy	slightly smaller	equal
cal	pyr	equal	moderately larger
cal	cal	slightly larger	moderately larger
com	Winter Nelis	equal	slightly larger
uss	Old Home	moderately smaller	slightly smaller
cal	none	--------	equal

All rootstock/interstock unions were at the ground line and were smooth.

Abbreviations:

uss	P. ussuriensis
cal	P. calleryana
com	P. communis
bet	P. betulaefolia
pyr	P. pyrifolia

interstock of Hung Guar Li, a strain of P. ussuriensis. Row 18 was Tolstoy interstock on P. ussuriensis rootstock and again both the Seckels and Anjous were in a poor state of vigor. The only other nearby row on P. ussuriensis rootstock was row 16 which had an Old Home interstock. While this row was of normal vigor it could not be used as a comparison row due to the readiness with which Old Home develops roots so that both rootstock and interstock have root systems.

The only other row with P. ussuriensis rootstock and not Old Home interstock was row 6. This had Variolosa as an interstock and was of normal size and vigor.

Tree vigor as related to rootstock

The differences in tree condition and vigor associated with rootstocks were equally as marked as those associated with interstocks. As mentioned above, row 13, P. ussuriensis root with Hung Guar Li interstock, was in very poor condition while the adjoining row 14 had the same interstock but P. calleryana rootstock and was in good vigor. The same was true of rows 18, 19, and 20. They all had Tolstoy interstock but row 18, with P. ussuriensis rootstock, was in very poor condition while rows 19 and 20 on P. calleryana and P. communis rootstocks were in good condition. While the soil was variable in these areas, the variable factors cut across the rows so that in no wise could they be considered responsible for the change in vigor which followed each row its full length.

Contrasted with this association of rootstock and lack of tree vigor, there was an association of rootstock and improved vigor. The outstanding case of this was with P. betulaefolia.

Row 4 was P. betulaefolia rootstock with Old Home interstock and row 9 was P. betulaefolia with Variolosa interstock. The Anjous on these two rows were a little larger than any others and the Seckels were outstanding in size and vigor.

Yield as related to rootstock

The yield of Anjou on P. betulaefolia was good but not outstanding, whereas Seckel yielded much better on P. betulaefolia than on any other rootstock in 1958 and fruit size was also larger. While actual records were not obtained in 1959, preharvest observation indicated that these rows would again have the largest yield and that the fruit size difference might be even more in their favor.

The relationship between rootstock and yield is clearly shown in Table 15. The production of Seckels on two interstocks is uniformly best on P. betulaefolia rootstock. Production on P. communis and P. calleryana rootstocks is materially less and production on P. pyrifolia and P. ussuriensis is still lower, being only about half that on P. betulaefolia.

Trunk circumference, yield and fruit size as related to rootstock and interstock

As pointed out earlier, Old Home trunks are larger than Variolosa under Seckel but smaller than Variolosa under Anjou. In these cases, yield tends to follow trunk circumference (see Table 13). Seckel on Old Home slightly outyields Seckel on Variolosa, with the conspicuous exception of where they are on P. betulaefolia rootstock. However, Anjou on Variolosa slightly outyields Anjou on Old Home with the conspicuous exception of where they are on P. communis rootstock.

TABLE 15

ANJOU AND SECKEL YIELD IN BOXES AS RELATED TO INTERSTOCK AND ROOTSTOCK

	Rootstock					
Variety/interstock	bet	com	cal	pyr	uss	Ave.
Anjou/Variolosa	9.0	7.0	8.0	6.0	5.0	7.0
Anjou/Old Home	8.0	9.0	5.7	5.0	3.0	6.1
Seckel/Old Home	7.3	4.8	5.8	3.7	4.8	5.3
Seckel/Variolosa	8.3	4.4	5.2	3.2	3.7	5.0
Average	8.2	6.3	6.2	4.5	4.1	5.0

Abbreviations:

bet	*P. betulaefolia*
com	*P. communis*
cal	*P. calleryana*
pyr	*P. pyrifolia*
uss	*P. ussuriensis*
Ave.	Average

Seckel sizes were largest from trees on _P_. _betulaefolia_ rootstock with both Old Home and Variolosa interstocks. The Anjous were largest on trees with Old Home and Variolosa interstocks on _P_. _communis_ rootstock and Variolosa interstock on _P_. _calleryana_ rootstock. These yield and size records are for 1958.

Stock-Scion Relationships in the Nursery

After two years of growth in the nursery all groups of trees had responded very much alike. The trees had grown well, being branched and four to six feet tall. The amount of top growth produced was the same regardless of the parentage of the seedling stock, the height of budding, the microclimate surrounding the bud, or the tissue in which the buds were placed. The Bartlett budlings grew a little better than the Comice but this is in line with nursery experience and is probably due to a complication with a virus disease in the Comice. Examination of the unions at this time did not disclose any tendency of the Comice scions to overgrow the stocks or the stocks to overgrow the Bartlett scions, even where the buds were placed high. The relationship of scion to stock was the same in Comice as it was in Bartlett. The scions in both cases were slightly smaller than the stock, which is normal, due to the difference of one year in age.

Storage and Dessert Quality as Related to Interstock and Rootstock

Fruit was taken from all four blocks at the time of commercial harvest. Twenty-pear samples were picked for storage from the lower part of the trees. This fruit was selected from the north and south sides and from shaded and exposed positions. At harvest time all Bosc and Seckel fruit appeared to be of excellent quality regardless of rootstock or interstock. However, with the Anjou variety the external appearance of the fruit varied with the rootstock. Anjous from trees on P. communis and P. calleryana had good finish with no evidence of black-end. On the other hand, Anjous from trees on P. pyrifolia, P. ussuriensis and P. betulaefolia roots were lacking in finish, the skin being coarse and of a pebbly texture, and a few of them also showed black-end. In addition there was some fruit from trees on P. betulaefolia roots which were affected with cork spot. Fruits visibly affected by these physiological troubles were not taken in the samples. These differences were related to certain rootstocks. There were no differences noted in appearance of fruit due to interstock. The crop size was moderately large for all varieties.

The differences in dessert quality evidenced in this test are associated with a long storage period and would not be expected to appear in fruit at harvest time or after a moderate period of storage. Fruit quality and marketability were based on color and appearance of the fruit, dessert quality, texture, shrivel and breakdown.

Interstock influence on storage and dessert quality of Bosc pears

This Bosc fruit from orchard number 1 was all produced on trees on _P_. _communis_ rootstock but some had no interstock, some had Comice interstock, and some had Seckel interstock. When harvested on September 12, the pears all appeared to be of excellent quality regardless of interstock. Their maturity as indicated by testing a ten-pear sample with the Oregon pressure tester was comparable, being as follows:

Bosc/_P_. _communis_	22.0 lbs.
Bosc/Comice/_P_. _communis_	23.2 lbs.
Bosc/Seckel/_P_. _communis_	23.2 lbs.

When removed from storage 128 days later, all the fruit still had very good color and appearance. Up until the time the fruit actually softened no difference was noted between lots. However, as the fruit softened the specimens grown on trees on _P_. _communis_ rootstocks with no interstock developed normally in all respects and when ripe were of very good quality and very good texture (Table 16). The fruit from trees with either Comice or Seckel interstocks remained hard and failed to ripen properly, being only fair in quality and poor in texture. There was evidence the fruit of these lots had reached the end of its storage life prior to its removal from storage. The fruit of lot 1 had not exhausted its storage life before removal from storage and, hence, proceeded to ripen in a normal manner.

Interstock influence on storage and dessert quality of Winter Nelis pears

This Winter Nelis fruit was produced on trees on _P_. _communis_ rootstock but one lot came from trees with no interstock and one lot

TABLE 16

STORAGE AND DESSERT QUALITY OF BOSC PEARS AS INFLUENCED BY CERTAIN INTERSTOCKS

Lot No.	Interstock	Color and appearance	Dessert quality	Texture	Core breakdown	Harvest pressure test	Remarks
1	none	very good	very good	very good	none	22.0 lbs.	Fruit ripened in normal manner.
2	Comice	very good	fair	poor	none	23.2 lbs.	Fruit failed to ripen properly.
3	Seckel	very good	fair	poor	none	23.2 lbs.	Fruit failed to ripen properly.

Date of removal from storage, 1/17/59. Fully ripe, 1/28/59. Stored at 31° F. Ripened at 65° F.

All lots grown on P. communis rootstock.

from trees with Bartlett interstock. After 240 days in storage the fruit in both lots ripened normally and developed very good quality. (Table 17).

Interstock influence on storage and dessert quality of Anjou pears

The Anjous in this test from orchard number 1 were on _P_. _communis_ rootstock but some trees had no interstock and some had interstocks of Comice or Clairgeau. One sample was from Anjou/Howell/Clairgeau/_P_. _communis_.

After 190 days in storage at 31° F the fruit was removed and ripened. All the fruit, whether from trees with no interstock, one interstock, or two interstocks, ripened normally and developed good quality (Table 18). The following is a more detailed description of these lots when removed from storage, and when ripe.

Fruit from Anjou/Comice/P. _communis_ when removed from storage was generally firm, with a uniform pale green color. There was no evidence of cork spot or hard-end. It was a good appearing lot.

The fruit was fully ripe in five days with an attractive greenish-yellow color. It had a tendency to ripen quickly and become dry in texture. It was a fairly good lot except for this tendency which resulted in lack of shelf-life. The dessert quality was good for a short period.

Fruit from Anjou/_P_. _communis_ when removed from storage was generally firm with a greenish-yellow color, smooth and attractive. There was some evidence of cork spot on a few specimens.

The fruit was fully ripe in five days with a uniform greenish-yellow color, smooth and attractive. The dessert quality was good.

TABLE 17

STORAGE AND DESSERT QUALITY OF WINTER NELIS PEARS AS INFLUENCED BY BARTLETT INTERSTOCK

	Winter Nelis	Winter Nelis/Bartlett
Date of harvest	9/27/58	9/27/58
Pressure test	29.3 lbs.	27.9 lbs.
Days in storage	240	240
Dessert quality	very good	very good

Both lots from trees on *P. communis* rootstock.

TABLE 18

STORAGE AND DESSERT QUALITY OF ANJOU PEARS AS INFLUENCED BY VARIOUS INTERSTOCKS

	Interstock			
	None	Comice	Clairgeau	Howell/ Clairgeau
Date of harvest	9/16	9/16	9/16	9/16
Pressure test	19.2	20.0	21.9	19.6
Days in storage	190	190	190	190
Days in ripening room	5	5	8	5
Dessert quality	good	good	good	good

All lots grown on P. communis rootstock

This lot rates among the best except for a slight tendency to ripen quickly. The cork spot was not evident in the ripened fruit.

Fruit from Anjou/Clairgeau/P. communis when removed from storage was generally firm with a uniform greenish-yellow color. There was some evidence of cork spot in a few specimens. The fruit was generally smooth and attractive. It was a fairly good lot.

The fruit was fully ripe in eight days, with a greenish-yellow color. Its dessert quality was good. Its value was depreciated somewhat by the evidence of cork spot which became more severe as ripening progressed.

Fruit from Anjou/Howell/Clairgeau/P. communis when removed from storage was firm, a uniform greenish-yellow, smooth and attractive. There was no evidence of cork spot or hard-end. It was a good lot.

The fruit was fully ripe in five days. The dessert quality was good. It was a very good lot except for a slight tendency to ripen quickly and become dry in texture.

Rootstock influence on storage and dessert quality of Anjou pears

Samples of Anjou fruit produced on trees growing on five different rootstocks were stored for 210 days, then ripened. No interstocks were involved. The trees were worked high enough to preclude scion rooting, therefore any differences in fruit quality should be a result of scion-rootstock relationship. This test clearly shows a difference in quality associated with rootstock (Table 19). Fruits from trees on P. communis rootstock developed uniformly good quality. Fruit from trees on the other rootstocks was highly variable in quality. A few specimens ripened with good quality but in general the lots were decidedly inferior to the one from trees on P. communis rootstock and were not considered marketable.

TABLE 19

STORAGE AND DESSERT QUALITY OF ANJOU PEARS
AS INFLUENCED BY CERTAIN ROOTSTOCKS

Rootstock	Harvest date	Days in storage	Cork spot or hard-end	Dessert quality
P. communis	9/4	210	none	good
P. betulaefolia	9/4	210	some	poor
P. calleryana	9/4	210	none	poor
P. ussuriensis	9/4	210	some	poor
P. pyrifolia	9/4	210	some	poor

The following is a more detailed description of these lots at harvest, when removed from storage, and when ripe.

Fruit from Anjou/P. communis when harvested was well sized with good finish. There was no evidence of hard-end or cork spot.

When removed from cold storage the fruit was attractive, uniform in color and condition. There was no breakdown, hard-end or cork spot.

The fruit continued uniform in color and condition and with fine finish to maturity. There was no evidence of breakdown, hard-end or cork spot. The fruit developed good dessert quality. While not of top quality, this fruit was still marketable. This was by far the best of these lots.

Fruit from Anjou/P. betulaefolia when harvested was well sized and with good finish but there was some evidence of hard-end and cork spot.

When removed from cold storage some specimens were breaking down and there was some evidence of hard-end and cork spot. There was much variation in color and condition.

The fruit continued to break down in the ripening room with much variation in color and condition. Hard-end specimens failed to ripen. Dessert quality was poor. The lot as a whole was not marketable due to breakdown.

Fruit from Anjou/P. calleryana when harvested was well sized with good finish. There was no evidence of hard-end or cork spot.

When removed from storage there was slight variation in color and condition. The fruit was more mature than that from P. communis rootstock.

Fifteen per cent of the specimens broke down while in the ripening room. A few specimens ripened with fairly good dessert quality. Extreme variability of color and condition was characteristic of this lot, but as a whole it was of poor quality and unmarketable due to breakdown.

Fruit of Anjou/P. ussuriensis when harvested was lacking in size and finish and there was some evidence of hard-end.

When removed from cold storage there was considerable variation in color and condition and there was some evidence of hard-end.

At maturity there was much variation in color and condition. Ten per cent of the specimens broke down during ripening. Hard-end specimens failed to soften. This lot was poor and was not marketable due to breakdown and hard-end.

Fruit from Anjou/P. pyrifolia when harvested was somewhat undersized and lacking in finish but there was no evidence of hard-end or cork spot.

When removed from storage ten per cent of the specimens had broken down. There was much variation in color and condition and there was some evidence of hard-end which had not been noticeable at harvest time.

The fruit continued to break down in the ripening room. Hard-end specimens failed to soften. A few specimens developed fair dessert quality. There was much variation in color and condition. The lot as a whole was not marketable and was the poorest of these lots.

Rootstock and interstock influence on storage and dessert quality of Anjou pears

Results here are not as clear cut because of the presence of different rootstocks and interstocks and because of soil variability within the block. However, with the influence of rootstock on quality already well demonstrated, and as the variable soil factors crossed the rootstock-interstock combinations, it is obvious that certain rootstock-interstock influences do exist. These can best be seen in Table 20. These will be discussed first from the standpoint of rootstocks.

Fruit from trees on P. ussuriensis, P. pyrifolia and P. calleryana rootstocks were all of poor quality. Of the fourteen different rootstock-interstock combinations involving these three rootstocks and the three replications represented here, only one of these, Variolosa/ P. pyrifolia, produced fruit which ripened with sufficient quality to be classed as marketable and it had only fair quality. From this it appears that these three rootstocks so adversely affect Anjou quality that the interstocks used were unable to improve it markedly.

Of the two interstock combinations with P. betulaefolia, one produced poor quality pears which were not marketable while the other produced pears of good quality. It should be noted here that while no cork spot or hard-end developed in the test fruit from the Anjou/Variolosa/P. betulaefolia combination, it did occur on that combination in the orchard in amounts about equal to that produced by the Anjou/Old Home/ P. betulaefolia combination. The P. betulaefolia root was by far the worst one from the standpoint of cork spot in Anjou.

Four of the five lots of fruit from trees on P. communis were good. These compare well with the fruit from trees on P. communis rootstock with no interstock (see Table 19). The fifth lot was a combination involving Tolstoy interstock which is discussed below.

In reviewing these combinations from the standpoint of the interstock influence, it is found that Tolstoy is outstandingly poor. Tolstoy

TABLE 20

STORAGE AND DESSERT QUALITY OF ANJOU PEARS AS INFLUENCED BY ROOTSTOCKS AND INTERSTOCKS

	Rootstock				
Interstock	*P. communis*	*P. betulaefolia*	*P. calleryana*	*P. pyrifolia*	*P. ussuriensis*
Old Home	good	poor*	very poor*	very poor*	very poor*
Old Home	good		very poor*		fair*
Old Home					poor*
Variolosa	good	good	poor*	fair	poor*
Farmingdale					fair*
Longworth					poor*
Hung Guar Li			very poor*		poor*
Winter Nelis	good				
P. pyrifolia			very poor*		
P. calleryana			very poor*		
Tolstoy	very poor*		very poor*		very poor*

Stored at 31° F for 180 days. Removed from storage 3/23/59. Ripened at 65° F.

* Indicates lot was not marketable due to poor quality, shrivel or breakdown.

was used in combination with three different rootstocks and all of these combinations produced fruit which was very poor. The fruit from the Anjou/Tolstoy/P. communis combination was the only fruit produced by trees on P. communis rootstock which rated less than good. Not only was this fruit very poor, but much of it was ripe and breaking down when removed from cold storage and was in the poorest condition of any lot at that time. On the other hand Variolosa interstock on Oriental roots seemed to improve the fruit quality slightly and maintained good quality when grown on P. communis rootstock.

The condition of some of the fruit as it came from cold storage was not well correlated with its quality after being ripened in the ripening room. This is shown in Table 21.

Of the six samples rated good when removed from cold storage, four were on P. calleryana rootstock. After a few days in the ripening room these began to break down and by the time they were ripe, they were of very poor quality and many were completely broken down. This behavior was characteristic of all lots of Anjous produced by trees on P. calleryana rootstock.

Of the three lots from trees with Tolstoy interstock, one rated good, one fair and one poor when removed from cold storage, but all were very poor when ripe. It is interesting to note that the poorest lot of all at the time of removal from cold storage was from trees with Tolstoy interstock and P. communis rootstock.

While there were variations in maturity as indicated by the pressure test, and in soluble solids, these were minor and could not be

TABLE 21

COMPARISON OF ANJOU PEARS FROM TREES WITH VARIOUS INTERSTOCK-ROOTSTOCK COMBINATIONS WHEN REMOVED FROM COLD STORAGE AND WHEN FULLY RIPE

Condition when taken out of storage	Dessert quality when ripe		
	Good	Fair to poor	Very poor
Good	Old Home/com Old Home/com Winter Nelis/com		Old Home/cal Old Home/cal Tolstoy/cal cal/cal
Fair	Variolosa/com Variolosa/bet	Variolosa/pyr Farmingdale/uss Longworth/uss Old Home/uss	Old Home/uss Hung Guar Li/cal Tolstoy/uss
Poor		Old Home/bet Old Home/pyr Old Home/uss Variolosa/uss Hung Guar Li/uss Variolosa/cal	Tolstoy/com pyr/cal

Abbreviations:		
	com	*P. communis*
	bet	*P. betulaefolia*
	pyr	*P. pyrifolia*
	uss	*P. ussuriensis*
	cal	*P. calleryana*

correlated to fruit quality (Table 22). The fruit from Anjou/Winter Nelis/P. communis had a pressure test of 25.1 lbs. and a soluble solids test of 12.7 per cent and rated good, while the combination of Anjou/Tolstoy/P. communis, rated one of the poorest, had a pressure test of 25.7 lbs. and a soluble solids test of 12.7 per cent.

A detailed description of the quality of fruit produced by each combination follows:

Fruit from Anjou/Old Home/P. ussuriensis from Row 1 when removed from storage was generally firm with a uniform pale-green color. There was no evidence of cork spot or hard-end. The finish was only mediocre.

The fruit was fully ripe in seven days. The color was generally pale green. It had a tendency to become dry in texture quickly. Dessert quality was very poor, some specimens ripening with a spongy feel. Storage life was short and the fruit was not marketable.

Fruit from Anjou/Old Home/P. calleryana from Row 2 when removed from storage was generally firm, uniformly pale green, smooth and attractive, with no evidence of cork spot or hard-end.

The fruit was fully ripe in four days, with a uniform pale green color. Many specimens broke down after four days in the ripening room. It was rated very poor due to this rapid breakdown and was not marketable.

Fruit from Anjou/Old Home/P. communis from Row 3 when removed from storage was generally firm, uniformly pale green, and with no evidence of cork spot or hard-end. The fruit was well formed, smooth, and attractive.

The fruit was fully ripe in seven days, a uniform pale green, with a slight tendency to yellow. Dessert quality was good. This was by far

TABLE 22

DESSERT QUALITY OF ANJOU PEARS IN ORCHARD NO. 3 AS RELATED TO INTERSTOCK, ROOTSTOCK, PRESSURE TEST, AND SOLUBLE SOLIDS CONTENT AT HARVEST TIME

Row	Interstock	Rootstock	Harvest pressure test-lbs	Per cent soluble solids	Dessert quality
1	Old Home	uss	24.3	13.5	very poor
2	Old Home	cal	24.0	13.0	very poor
3	Old Home	com	23.9	14.5	good
4	Old Home	bet	25.3	14.5	poor
5	Old Home	pyr	25.3	14.0	poor
6	Variolosa	uss	26.9	13.3	poor
7	Variolosa	cal	25.8	12.7	poor
8	Variolosa	com	24.5	14.3	good
9	Variolosa	bet	26.3	12.5	good
10	Variolosa	pyr	26.1	13.3	fair
11	Farmingdale	uss	25.7	14.5	fair
12	Longworth	uss	26.3	14.7	poor
13	Hung Guar Li	uss	25.5	12.7	poor
14	Hung Guar Li	cal	26.1	13.7	very poor
15	Old Home	com	24.5	13.0	good
16	Old Home	uss	24.3	14.2	fair
17	Old Home	cal	25.7	12.5	very poor
18	Tolstoy	uss	25.2	13.0	very poor
19	Tolstoy	cal	25.6	13.7	very poor
20	Tolstoy	com	25.7	12.7	very poor
21	pyr	cal	23.8	14.0	very poor
22	cal	cal	26.0	12.5	very poor
23	Winter Nelis	com	25.1	12.7	good
24	Old Home	uss	27.1	13.5	poor

Abbreviations:

uss	*P. ussuriensis*
cal	*P. calleryana*
com	*P. communis*
bet	*P. betulaefolia*
pyr	*P. pyrifolia*

the best of these lots; while not at its best it was still marketable on the basis of its quality and condition.

Fruit from Anjou/Old Home/P. betulaefolia from Row 4 when removed from storage was generally firm. There was much variation in color and considerable evidence of cork spot and hard-end. It was a very poor lot with a few specimens breaking down following cork spot.

The fruit was fully ripe in seven days. There was much variation in color. Ten per cent of the specimens broke down during ripening. The lot as a whole was unmarketable and the final rating was poor.

Fruit from Anjou/Old Home/P. pyrifolia from Row 5 when removed from storage was generally firm. There was much variation in color and some evidence of cork spot and hard-end.

The fruit was fully ripe in seven days. There was considerable variation in color and the hard-end specimens failed to ripen. The lot as a whole was not marketable, although some specimens developed fairly good dessert quality. The final rating was poor.

Fruit from Anjou/Variolosa/P ussuriensis from Row 6 when removed from storage was generally firm. There was much variation in color and some evidence of cork spot and hard-end.

The fruit was fully ripe in seven days. There was considerable variation in color and the hard-end specimens failed to ripen, but some others developed fair dessert quality. The lot as a whole rated poor and was unmarketable.

Fruit from Anjou/Variolosa/P. calleryana from Row 7 when removed from storage had considerable variation in color. The fruit was generally firm although some specimens were firm ripe. There was some evidence of cork spot. The lot rated poor at the time of removal from cold storage.

The fruit was fully ripe in seven days. There was much variation in color. Some specimens broke down during ripening, while others developed fair dessert quality. The lot rated poor because of breakdown and irregularity of maturity. The lot as a whole was not marketable.

Fruit from Anjou/Variolosa/P. communis from Row 8 when removed from storage was generally firm with a pale green color showing a slight yellowing on some specimens. No evidence of cork spot or hard-end showed.

The fruit was fully ripe in seven days. The color was generally pale green with yellowing on some specimens. While not at its best, this lot rated good and was still marketable, on the basis of condition, appearance and dessert quality.

Fruit from Anjou/Variolosa/P. betulaefolia from Row 9 when removed from storage was generally firm, a uniform pale green with no evidence of cork spot or hard-end. The fruit was well formed with good finish.

The fruit was fully ripe in seven days, a uniform pale green, and the dessert quality was good. It was a good lot but not the equal of lot 3. While not at its best, this fruit was still marketable.

Fruit from Anjou/Variolosa/P. pyrifolia from Row 10 when removed from storage was generally firm, a uniform pale green with no evidence of cork spot or hard-end.

The fruit was fully ripe in eight days, a uniform pale green with good finish and appearance. The dessert quality was fair and while not equal to lot 3 was still marketable.

Fruit from Anjou/Farmingdale/P. ussuriensis from Row 11 when removed from storage was generally firm, a uniform pale green with no evidence of cork spot or hard-end.

The fruit was fully ripe in seven days. It was generally pale green except for a few specimens which developed incipient hard-end in the ripening room. Hard-end specimens failed to ripen. Normal specimens developed fair dessert quality. The lot as a whole was not marketable because of hard-end condition.

Fruit from Anjou/Longworth/P. ussuriensis from Row 12 when removed from storage was generally firm, a uniform pale green color with no evidence of cork spot or hard-end. The fruit was well formed and smooth.

The fruit was fully ripe in seven days and generally pale green. Many specimens failed to ripen and dessert quality was poor. Normal specimens had a tendency to become dry in texture quickly during ripening. The lot was unmarketable.

Fruit from Anjou/Hung Guar Li/P. ussuriensis from Row 13 when removed from storage was generally firm with much variation in color. There was some breakdown obviously due to cork spot. The fruit was poorly shaped and unattractive. There was some evidence of hard-end.

The fruit was fully ripe in seven days with much variation in color. Hard-end specimens failed to ripen. The dessert quality was fair in some specimens but poor in others. The lot as a whole was not marketable due to breakdown and hard-end.

Fruit from Anjou/Hung Guar Li/P. calleryana from Row 14 when removed from storage was generally firm, uniform pale green with no evidence of cork spot or hard-end.

The fruit was fully ripe in five days. It had a decided tendency to ripen quickly and break down quickly in the ripening room. The lot rated very poor. It was very short lived after removal from storage and was not marketable.

Fruit from Anjou/Old Home/P. communis from Row 15 when removed from storage was generally firm, with uniform pale green color and no evidence of cork spot or hard-end. The fruit was smooth and attractive, and rated high but not quite as good as lot 3.

The fruit was fully ripe in seven days, with uniform pale green color. The dessert quality was good. It rated among the best; while not of top quality this fruit was still marketable.

Fruit from Anjou/Old Home/P. ussuriensis from Row 16 when removed from storage was generally firm with uniform pale green color and no evidence of cork spot or hard-end. It rated only fair in attractiveness.

The fruit was fully ripe in seven days, with uniform pale green color. The dessert quality was fair. It had a tendency to become dry in texture shortly after removal from storage. Many specimens broke down after ripening. The lot was not marketable.

Fruit from Anjou/Old Home/P. calleryana from Row 17 when removed from storage was generally firm, a uniform pale green and showed no evidence of cork spot or hard-end. The fruit was smooth and well formed.

The fruit was fully ripe in five days and generally pale green. The fruit broke down quickly after removal from cold storage. It was unmarketable because of breakdown and complete lack of dessert quality, and was a very poor lot.

Fruit from Anjou/Tolstoy/P. ussuriensis from Row 18 when removed from storage was generally firm, a pale green color, and smooth and attractive. There was no evidence of cork spot or hard-end.

The fruit was fully ripe in five days, and generally pale green. The fruit broke down quickly after removal from cold storage and the dessert quality was very poor. It was not marketable.

Fruit from Anjou/Tolstoy/P. calleryana from Row 19 when removed from storage was generally firm, smooth and well formed. There was no evidence of cork spot or hard-end.

The fruit was fully ripe in five days and broke down quickly after removal from cold storage. The dessert quality was very poor. The lot was unmarketable due to premature ripening and breakdown. This was one of the poorest lots.

Fruit from Anjou/Tolstoy/P. communis from Row 20 when removed from storage was ripe and breaking down. This was the poorest lot of all as it came from cold storage. It was of no market value at that time of year.

The fruit was fully ripe in four days. Most of the specimens were completely broken down after four days in the ripening room. It was a very poor lot.

Fruit from Anjou/P. pyrifolia/P. calleryana from Row 21 when removed from storage was generally firm, a uniform pale green, and with no evidence of cork spot or hard-end.

The fruit was fully ripe in four days. Most of the specimens broke down shortly after removal from cold storage. The lot was not marketable due to this condition and rated very poor.

Fruit from Anjou/P. calleryana/P. calleryana from Row 22 when removed from storage was generally firm, a uniform pale green, with no evidence of cork spot or hard-end. It was smooth and attractive.

The fruit was fully ripe in five days but completely broken down after four days in the ripening room. While this lot rated among the best at the time of removal from cold storage it rated among the poorest after its performance in the ripening room.

Fruit from Anjou/Winter Nelis/P. communis from Row 23 when removed from storage was generally firm, uniform pale green, fairly smooth and attractive. There was no evidence of cork spot or hard-end. It was a good lot.

The fruit was fully ripe in seven days with a pale green color. The dessert quality was good. While this lot was not equal to lot 3, it rated high from the standpoint of shelf life.

Fruit from Anjou/Old Home/P. ussuriensis from Row 24 when removed from storage had considerable variation in color and maturity. Some specimens were fully ripe. There was some evidence of cork spot. It was a poor lot.

The fruit was fully ripe in seven days. Some specimens broke down completely during ripening and others failed to ripen. There was much variation in color, quality and condition. The lot was poor and not marketable.

Rootstock and interstock influence on storage and dessert quality of Seckel pears

Here again both the rootstocks and interstocks seem to exert an influence on fruit quality as shown in Table 23. Among the rootstocks, _P. ussuriensis_, _P. pyrifolia_ and _P. calleryana_ tend to impart poor quality. _P. communis_ has the potential for good quality and _P. betulaefolia_, with the two interstocks used, produced good quality.

Tolstoy again falied as an interstock, imparting at best only fair dessert quality. Considering low quality, shrivel and breakdown none of the three lots was marketable.

Variolosa interstock again looked good, fruits from trees with this interstock being the only ones to develop good quality on _P. pyrifolia_ and _P. calleryana_ rootstocks. The Seckel quality was also good where Variolosa was used in combination with _P. betulaefolia_ but only fair with _P. communis_ and _P. ussuriensis_.

Winter Nelis and Variolosa used as interstocks on _P. communis_ rootstock appear to have lowered the fruit quality compared to the Old Home interstock. This was not a true comparison as the Old Home interstock had rooted, so that there was not only an Old Home interstock but Old Home roots as well. A detailed record of the quality of Seckel as it was influenced by the rootstocks and interstocks appears in Table 24.

The differences in fruit quality in this test were not related to the soluble solids content of the fruit or to maturity as indicated by the pressure test. This is shown in Table 25 where high, average and low tests appear both in high quality lots and in low quality lots.

TABLE 23

STORAGE AND DESSERT QUALITY OF SECKEL PEARS AS RELATED TO ROOTSTOCK AND INTERSTOCK

	Rootstock				
Interstock	*P. communis*	*P. betulaefolia*	*P. calleryana*	*P. pyrifolia*	*P. ussuriensis*
Old Home	good	very good	fair*	poor*	fair
Old Home	good		poor*		poor*
Old Home					fair
Variolosa	fair	good	good	good	fair
Farmingdale					fair*
Longworth					fair
Hung Guar Li			fair*		fair*
Winter Nelis	fair*				
P. pyrifolia			fair		
P. calleryana			fair		
Tolstoy	fair*		fair*		poor*
none			fair		

Harvested 8/23/58. Stored at 31° F for 100 days. Removed from storage 12/1/58. Ripened at 65° F.

* Indicates lot was not marketable due to poor dessert quality, shrivel or breakdown.

TABLE 24

STORAGE AND DESSERT QUALITY OF SECKEL PEARS AS INFLUENCED BY ROOTSTOCK AND INTERSTOCK

Row No.	Interstock-rootstock combination	Color and appearance	Dessert quality	Texture	Shrivel	Mealy breakdown	Remarks
1	Old Home/uss	fair	poor	fair	moderate	moderate	Not marketable.
2	Old Home/cal	fair	fair	fair	severe	moderate	Not marketable.
3	Old Home/com	fair	good	fair	moderate	slight	Average.
4	Old Home/bet	good	very good	good	slight	none	Best of lot.
5	Old Home/pyr	poor	poor	poor	moderate	severe	Not marketable.
6	Variolosa/uss	fair	fair	fair	moderate	none	Average
7	Variolosa/cal	fair	good	good	slight	none	Above average.
8	Variolosa/com	fair	fair	fair	severe	none	Below average.
9	Variolosa/bet	fair	good	good	moderate	none	Abovo average.
10	Variolosa/pyr	fair	good	good	slight	none	Above average.
11	Farmingdale/uss	fair	fair	fair	severe	moderate	Not marketable.
12	Longworth/uss	fair	fair	fair	severe	none	Below average.
13	Hung Guar Li/uss	poor	fair	fair	severe	moderate	Not marketable.
14	Hung Guar Li/cal	fair	fair	fair	severe	moderate	Not marketable.
15	Old Home/com	fair	good	good	slight	none	Above average.
16	Old Home/uss	fair	fair	fair	severe	none	Below average.
17	Old Home/cal	fair	poor	poor	severe	severe	Not marketable.
18	Tolstoy/uss	poor	poor	fair	severe	moderate	Not marketable.

TABLE 24 (cont.)

Row No.	Interstock-rootstock combination	Color and appearance	Dessert quality	Texture	Shrivel	Mealy breakdown	Remarks
19	Tolstoy/cal	fair	fair	fair	moderate	moderate	Not marketable.
20	Tolstoy/com	fair	fair	fair	severe	moderate	Not marketable.
21	pyr/cal	fair	fair	fair	moderate	none	Average
22	cal/cal	fair	fair	fair	severe	none	Average.
23	Winter Nelis/com	fair	fair	fair	severe	moderate	Not marketable.
24	Old Home/uss	fair	fair	fair	moderate	none	Average.
25	none	fair	fair	fair	severe	none	Below average.

Harvested 8/23/58. Stored at 31° F for 100 days. Removed from storage 12/1/28.
Ripened at 65° F.

Abbreviations:		
	uss	*P. ussuriensis*
	cal	*P. calleryana*
	com	*P. communis*
	bet	*P. betulaefolia*
	pyr	*P. pyrifolia*

TABLE 25

DESSERT QUALITY OF SECKEL PEARS GROWN ON VARIOUS INTERSTOCK-ROOTSTOCK COMBINATIONS AS RELATED TO PRESSURE TEST AND SOLUBLE SOLIDS CONTENT AT HARVEST TIME

Row	Interstock	Rootstock	Harvest pressure test-lbs	Per cent soluble solids	Dessert quality
1	Old Home	uss	25.0	15.8	poor
2	Old Home	cal	25.1	14.5	fair
3	Old Home	com	26.2	16.0	good
4	Old Home	bet	26.5	14.7	very good
5	Old Home	pyr	26.9	15.7	poor
6	Variolosa	uss	25.3	14.7	fair
7	Variolosa	cal	26.3	15.7	good
8	Variolosa	com	26.7	16.3	fair
9	Variolosa	bet	27.9	15.7	good
10	Variolosa	pyr	26.1	13.5	good
11	Farmingdale	uss	26.7	17.0	fair
12	Longworth	uss	26.7	16.3	fair
13	Hung Guar Li	uss	27.0	15.3	fair
14	Hung Guar Li	cal	25.6	15.7	fair
15	Old Home	com	25.5	16.0	good
16	Old Home	uss	24.7	15.0	fair
17	Old Home	cal	24.5	16.7	poor
18	Tolstoy	uss	25.3	15.8	poor
19	Tolstoy	cal	25.5	16.5	fair
20	Tolstoy	com	25.9	15.5	fair
21	pyr	cal	26.2	15.7	fair
22	cal	cal	26.4	16.3	fair
23	Winter Nelis	com	24.6	15.7	fair
24	Old Home	uss	24.8	16.8	fair
25	none	cal	25.2	14.3	fair

Abbreviations:

uss	_P. ussuriensis_
cal	_P. calleryana_
com	_P. communis_
bet	_P. betulaefolia_
pyr	_P. pyrifolia_

DISCUSSION

It helps the study of causes if the ultimate effects are well known. This was one reason for selecting old pear orchards to observe stock/scion relationships. In the four orchards studied, which ranged in age from 35 to 60 years, there were fifteen different scion or interstock varieties grafted onto five different rootstocks, making a total of thirty-one different combinations. There were also twenty-four interstock-variety combinations but as these all made relatively smooth unions they have been given little attention in this study. From this it should not be concluded that all varieties make smooth unions when used for topworking. Had Comice been used as a scion variety in topworking, it probably would have overgrown the interstock as it is notorious for doing so.

There are three types of uncongeniality involved in these scion/stock combinations. One is evident in the physical contours at the graft union. Another is more subtle and evidences itself in the storage capacity of the fruit even though the trees appear healthy. The third type has to do with yield and tree vigor even though the unions are smooth and appear to be physically congenial. Loss of vigor due to some combinations was quite evident in looking at the trees of orchard number 3, but due to soil irregularities no method was devised to measure it without bias.

This interpretation of congeniality goes beyond the actual successful uniting of tissues and establishment of a satisfactory system of conduction and translocation. It includes not only an apparently harmonious relationship between stock and scion tissues but also necessitates that all the essential auxins, vitamins, mineral elements, and elaborated foods be transported freely from one member to another and that none of them be of a toxic nature or create a toxic condition.

Among the thirty-one stock/scion combinations there were three types of unions formed: (1) where the circumference of the scion exceeded that of the rootstock, (2) where the stock and scion made a smooth union and were of the same size, (3) where the circumference of the roostock exceeded that of the scion.

These size differences between stock and scion could be attributed to a natural variation in growth habit and vigor among seedlings or to stock/scion uncongeniality. That different individuals vary in growth habit is apparent in observing commercial varieties which originated as seedlings. Comice, for instance, produces a proportionately large trunk while Bartlett develops a more slender trunk and when mature is a smaller tree than most of the other common varieties. It might then be expected that Comice would overgrow the rootstock and that the rootstock would overgrow Bartlett.

In the case of Comice, 60 per cent of the unions were smooth, 30 per cent of the Comice overgrew the rootstock, and 10 per cent of the rootstocks overgrew the Comice. However, the average size of the trunks with smooth or nearly smooth unions was greater than those where either the stock or scion materially exceeded the size of the other. It could be that the vigorous seedlings were the ones that united smoothly with the scion and helped develop large trunks. If this were the case, then all of the trees with unions overgrown by either stock or scion should be smaller than the trees with smooth unions. This was not the case. Over 30 per cent of the Comice trees with overgrown unions were larger than the average of trees with smooth unions. The same proportion held for Bosc and Clairgeau, but with Anjou it dropped to 20 per cent. This would indicate that there was a normal distribution of seedlings with varying vigor among the trees with smooth and overgrown unions, and that the overgrowth, whether by stock or scion, was a symptom of uncongeniality.

Webber (63) was also of the opinion that thorough congeniality is illustrated where the bud union is smooth and the trunk tapers gradually from the root upward. Argles (6) expressed a similar viewpoint.

An opposite viewpoint was expressed by Day (15) who said, "The French, or common pear seedling, is a vigorous stock, unites well with all pear varieties and makes a robust root system. The root crown often grows larger than the trunk of the scion. Such a condition is not unhealthy, some of the best Bartlett trees in an orchard are often of this type." Amos (4), and Bradford and Sitton (11) lend support to this viewpoint.

It seems true that some of the finest Bartlett trees are grown on rootstocks which overgrow the scion. This is likely due to inherent seedling vigor. It is also true that some Bartlett trees growing on rootstocks which overgrow the scion are smaller than average. These include most of the cases of extreme overgrowth and a few cases of moderate overgrowth, and would seem to result from uncongeniality. This would indicate that the relationship between Bartlett tree size and overgrowth is influenced by variations in seedling vigor but that there is also an element of uncongeniality present.

The fact that the amount of overgrowth increased with the height of the graft union was not surprising. Casual observation had long indicated this on pears. However with citrus the opposite often seems to be the case. Bitters _et al_. (10) found that certain citrus combinations were fairly smooth if worked above eight inches but uneven if worked near the ground. They call attention to the fact that walnuts behave similarly.

An explanation for such diverse responses is difficult. It may be that, as Roberts (48) points out, the rootstock stem exerts a considerable influence on the scion and, when high-worked, there would be more rootstock stem. By synthesizing or failing to synthesize some material this rootstock stem could be responsible for smooth unions in some cases and overgrown ones in others.

The relationship between length of interstock and trunk circumference could be influenced in the same manner. This would be expected in the case of a Comice interstock as it is a very vigorous grower and a large amount of it might be more effective in increasing trunk circumference than a small amount. However this increase also held true where Clairgeau was the interstock and it is no more vigorous than Anjou which was the top variety.

In observing the Bosc trees before harvest, it was evident that they were all carrying a maximum crop. This, then, was an ideal time to obtain yield data to determine the production capacity of the trees. While this does not indicate what the future yields will be, it does show what the trees are capable of producing. The Bosc trees were of uniform size, being pruned to the same height and the branches coming together in the centers of the rows. The Bosc trees with no interstock produced 19.9 boxes while the trees with Comice interstock produced 17.4 boxes per tree. Snyder et al. (54) found a significant influence of the interstock on yield, but as he was working with young trees, this may have been a measure of earliness of fruiting rather than ultimate yield.

Whether this difference in yield should be credited to a function of the Comice interstock as such or whether it is a result of inferior tree development resulting from topworking is not known. However, as trees with and without interstocks seemed to be fully loaded it would seem more logical that the lesser yield would result from inferior tree development. If this is the case it could not be said to be a result of uncongeniality, but rather of the less careful selection and training of branches on the topworked trees. The rapid growth of many shoots and branches on the topworked trees makes training a well-branched, well-balanced tree more difficult than that of a nursery tree.

There were considerable differences in yield of Anjous and Seckels due to rootstock and interstock. These were due to differences in tree size and not to a failure of the tree to set and produce a crop. They were, however, direct effects of stock/scion uncongeniality.

The third form of expression of uncongeniality is an influence on fruit quality. This is impossible to measure with our commercial varieties as there is no standard of comparison. An uncongenial graft partner might improve quality as well as lower it. Even fruiting a rooted cutting would not be a true index due to the difference between a rooted-scion root system and a seedling root system.

In view of this, some combination must be accepted as a standard and others compared to it. For pears it would be logical to accept trees on French root as standard. However, as there are some indications of uncongeniality existing even in this combination, as many variable factors as possible should be avoided. Individual trees of good vigor, on French rootstock, with no interstock, grafted at or near the ground line, with a smooth or nearly smooth union, and free from other obvious variables, would seem at present to constitute a good standard for comparison.

SUMMARY AND CONCLUSIONS

A study was made of various combinations of pear varieties, interstocks and rootstocks. Many pear varieties made a smooth union with the Pyrus species commonly used as rootstocks, provided the seedlings were grafted at the ground line. The higher the graft union was above the ground line the greater was the overgrowth. This overgrowth might be made by either stock or scion. The Bartlett variety was generally overgrown by _P. communis_ rootstock even when the union was at ground level.

These overgrowths are an evidence of uncongeniality and, within a variety, the average circumference of the trees with a smooth or nearly smooth union was greater than that of the trees where either the stock or the scion had materially overgrown the other. Bartlett was an exception to this, attaining the largest circumference where the rootstock had moderately overgrown the scion.

Long interstocks of Comice with Bosc or Anjou tops and of Clairgeau with Anjou tops resulted in trunks of greater circumference than did short interstocks of these same varieties.

There was some relation between trunk circumference and yield in sixty-year-old Bosc trees with and without Comice interstocks. The trees with Comice interstocks also produced less fruit than trees without an interstock.

Compared to ungrafted trees, the circumference of Winter Nelis trunks was less when a short Bartlett interstock was present but these same Bartlett interstocks were enlarged by the Winter Nelis tops. Unless a degree of dwarfing is desired, a medium-size tree variety, such as Bartlett, should not be used as an interstock for large-tree varieties.

Some interstocks and rootstocks materially affect tree size, vigor, yield and fruit size. This effect was not constant and varied in degree depending on the interstock/rootstock combination, and also varied with different scion varieties.

Bosc pears from trees with either Seckel or Comice interstocks failed to ripen and develop good quality late in their storage season. At the same time pears from Bosc trees growing directly on French rootstocks developed very good quality.

The dessert quality of Seckel and Anjou pears late in the storage season was materially affected by rootstocks and interstocks. P. communis rootstock was the only one consistently satisfactory for both varieties and should be the standard rootstock for use in the Rogue River Valley. P. betulaefolia with Old Home or Variolosa interstock was equally as good as a rootstock for Seckel. Because of a larger tree, greater yield, and larger fruit size, and the possibility of better quality fruit after storage, these combinations hold promise. P. betulaefolia is not a satisfactory rootstock for Anjou due to cork spot in the fruit. P. calleryana, P. pyrifolia and P. ussuriensis were unsatisfactory as rootstocks for Anjou and Seckel pears which were to be held for a long storage period. Where orchards are already established on these rootstocks, the fruit should not be stored for a long season. Tolstoy interstock induced poor quality in both varieties regardless of rootstock. Old Home interstock did not affect fruit quality and was generally satisfactory as an interstock. Variolosa interstock may have improved quality when used in combination with Oriental rootstocks.

Comice and Bartlett buds were placed in root tissue and stem tissue of seedlings of known parentage in the nursery. After two years of growth, no differences in tree vigor or scion/stock ratio were in evidence.

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BIOGRAPHICAL NOTES

Clifford Bernard Cordy was born November 13, 1906 at Portland, Oregon. He moved to Napa, California at an early age where he was raised on a fruit farm and attended public schools. He returned to Oregon in 1926 to attend Oregon State College from which he was graduated in 1930 with a Bachelor of Science degree in Agriculture. While there he attained membership in Alpha Zeta, Phi Sigma and Phi Kappa Phi honor societies.

After graduation he served as a Junior Pathologist in the United States Department of Agriculture for one year, and as Superintendent of the Sitka Alaska Experiment Station for one and one-half years. Following this he attended Michigan State College and was granted a degree of Master of Science in Agriculture in 1934.

Further brief study at the University of California was followed by employment in 1935 as County Extension Agent in Jackson County, Oregon. This position, with the status of Professor at Oregon State College, is still held. His efforts in developing a multi-million dollar fruit industry and in promoting community beautification were recognized in 1958 by being the recipient of the United States Department of Agriculture Superior Service Award.

Leaves of absence were taken in 1954-55 and in 1959 to continue studies leading to the degree of Doctor of Philosophy.

This dissertation was prepared under the direction of the chairman of the candidate's supervisory committee and has been approved by all members of that committee. It was submitted to the Dean of the College of Agriculture and to the Graduate Council, and was approved as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

June 5, 1961

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